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TITLE: Camouflage material

Abstract Text - ABTX (1):

A structure is provided comprising carbonaceous materials for absorbing and/or reflecting radiated energy or electromagnetic energy. The structure is useful for camouflage or for shielding electromagnetic radiation, especially microwaves.

Brief Summary Text - BSTX (5):

If the material to be developed into a camouflage structure is to be radar defeating, a common practice is to provide a substrate with a plurality of electrically conductive fibers or fibrils, these being typically either metal, such as stainless steel, or elemental carbon in the form of graphite fibers. A common material now being used includes a spun-bonded, non-woven fabric wherein one surface has adhered a plurality of randomly oriented metal fibrils. The non-woven fabric with the fibrils attached is then coated or laminated, usually on both sides, with a film or layer of a polymeric material, commonly polyvinyl chloride. The polyvinyl chloride (PVC) itself may be impregnated or filled with pigment, as disclosed in U.S. Pat. Nos. 4,034,375 and 4,435,465, to impart to the resulting material the desired responses in the visible or near visible electromagnetic radiation spectra, particularly visible, infrared and ultraviolet regions. Alternatively, the polyvinyl chloride can be further coated with a pigment-containing coating or paint to achieve a desired optical response characteristic.

Brief Summary Text - BSTX (6):

While the resulting product is generally suitable as a camouflage structure, certain disadvantages have appeared. One of these is that the radar reflectance characteristics initially built into the camouflage structure by virtue of the random disposition of metal fibers has a tendency to change when the finished camouflage structure is handled, crinkled, folded, or otherwise flexed in normal usage. The reason for this change in radar characteristics is not fully understood, but it has been established that different characteristics appear in the vicinity of the folds where broken particles accumulate and that, as a result, the camouflage can be distinguished by suitable radar analysis from the surrounding environment. Also, breakage of the semiconductors or other conductive

materials creates a change in continuity and contact resistance so that there are absorption changes that may result in detection.

Brief Summary Text - BSTX (7):

U.S. Pat. No. 4,495,239, discloses a camouflage structure, effective in the spectral range from visible light to radar waves, which comprises a base layer coated with a homogeneous metal layer reflective in the range of terrestrial thermal radiation as well as in the radar region of the spectrum (3 megahertz to 3,000 megahertz). The structure also has a surface resistivity of not more than 0.5 to 10 ohms per square cm and a subsequent coating of a camouflage paint containing pigments having reflective properties in the visible and near IR spectral regions that are similar to the natural background. A binder having high transparency in the 3-5 microns (.mu.m) and 8-14 .mu.m atmospheric windows of the far infrared, region of the spectrum is provided. The paint is applied so that its emissivity in those regions will vary over the surface of the material.

Brief Summary Text - BSTX (9):

U.S. Pat. No. 3,733,606 addresses the problem of detection by radar by using a camouflage structure consisting of a multi-layered material for absorbing and reflecting signals for defeating radar waves transmitted over different frequencies. At least one layer is a thin, non-homogeneous electrically conducting film and the other layers assist in providing both a two dimensional and three dimensional effect.

Brief Summary Text - BSTX (11):

U.S. Pat. No. 4,837,076 to Mc Cullough et al, which is herein incorporated by reference, discloses a class of carbonaceous fibers having the different degrees of electrical conductivity which may be used in the present invention.

Brief Summary Text - BSTX (13):

It is understood that the term "web" as used herein is intended to define a textile fabric which for simplicity is intended to include knitted, woven and non-woven textile materials mats, battings, laminates, and the like.

Brief Summary Text - BSTX (21):

The non-linear carbonaceous fibers used in the invention have a reversible deflection ratio of greater than about 1.2:1 and an aspect ratio of greater than about 10:1. When the fibers are graphitic and non-linear they have greater flexibility, and resistance to breaking

and abrasion as compared with linear graphitic fibers of the prior art. Other carbonaceous fibers which may be utilized are the metal coated fibers disclosed in copending application Ser. No. 366,804 filed Jun. 14, 1989, which is incorporated herein by reference.

Brief Summary Text - BSTX (22):

In accordance with one embodiment of the invention, there is provided a flexible structure having radar defeating detection by radar devices for use as camouflage. The structure comprises: 1) a first flexible electrically non-conductive layer of carbonaceous fibers and, 2) a second flexible electrically conductive layer of carbonaceous fibers for absorbing electromagnetic waves.

Brief Summary Text - BSTX (25):

The structure may include a bottom layer of radar reflective material so as to reflect any electromagnetic waves which pass through.

Brief Summary Text - BSTX (26):

Optionally, the structure on its upper surface may be provided with a layer of camouflage cloth, scrim or paint.

Brief Summary Text - BSTX (27):

Through the use of different plies or layers it is possible to provide a structure to absorb radar waves over a given band width by phase cancellation techniques. A ply can be added which is specific for infrared radiation. The use of non-linear fibers inherently produces a three dimensional effect so as to provide multi-angular absorption of the radiated waves.

Drawing Description Text - DRTX (3):

FIG. 2 shows a multi-layer camouflaging sheet, and

Detailed Description Text - DETX (2):

As shown in FIG. 1, a camouflage blanket 10 may be provided having a plurality of plies or layers of energy absorbing webs 11 and 12 for target signature reduction by absorbing incident radar waves and preventing heat and sound emanating from the protected equipment from reaching the upper surface of the blanket.

Detailed Description Text - DETX (3):

The blanket 10 comprises an electrically conductive fabric layer

11 of carbonaceous fibers for absorbing radar waves. A second layer 12 comprises a mat or batting of radar absorbing carbonaceous material. The mat or batting 12 is comprised of non-linear fibers so as to also function as a sound and thermal barrier. Optionally, discreet and/or magnetic particles dipole material may be randomly distributed throughout the layers.

Detailed Description Text - DETX (5):

The layer 13 may optionally be provided with a camouflaging about 10-100 mm thick, which contains inorganic metal compounds such as metal oxides and metal salts. Typically, said metal compounds are chromium oxide green, chromium oxide, hydrate green, titanium dioxide, iron oxide, zinc oxide, lead dioxide and ultramarine blue.

Detailed Description Text - DETX (6):

FIG. 2 shows a flexible camouflage means 20 comprising a plurality of plies or layers 21, 22, 23. The two outside layers 21, 23 may be made to cause a three dimensional effect for radar radiation by utilizing non-linear carbonaceous fibers 25 to provide differing angles of both incident and reflected waves. The layers 21, 22, 23 may be made of varying densities to provide different degrees of attenuation or the fibers 25 may comprise a mixture with fluorinated and/or metallized carbonaceous fibers.

Detailed Description Text - DETX (7):

The intermediate layer 22 includes the electrically conductive radar absorbing carbonaceous fibers 25. The fibers preferably have a diameter of approximately about 4 to 20 microns and various lengths of about a half-wavelength within the desired radar wavelength interval of, for example 1.5 to 30 cm. The fibers preferably have a total length of about 300 to 500 meter per square meter of the sheet and an average spacing of approximately 5 mm from one to another. Of course, the majority of the fibers are crossed by one or more other fibers. The fibers in the intermediate layer 22 may include fluorinated fibers 26.

Detailed Description Text - DETX (10):

The radar absorbing layer may include 5-10 percent by volume of randomly distributed dipole materials (not shown) having semiconductive properties.

Detailed Description Text - DETX (17):

In a second group, the carbonaceous fibers are classified as being partially electrically conductive (i.e., having a low conductivity)

and having a carbon content of greater than 65% but less than 85%. Low conductivity means that a 6K tow of fibers in which the precursor fiber have a single fiber diameter of from 4 to 20 microns, has a tow resistance of from about 4.times.10.sup.6 to 4.times.10.sup.3 ohms/cm (10.sup.-1 -10.sup.7 ohms per inch).

Detailed Description Text - DETX (19):

The electrical conductivity of the fibers may also be varied by varying the aspect ratios, length/diameter (l/d), of the fibers or by doping with a suitable substance such as arsenic, germanium, and the like.

Detailed Description Text - DETX (20):

The graphitic and the non-graphitic carbonaceous fibers of the three groups may be fluorinated as disclosed in aforementioned U.S. Pat. No. 4,857,394 so as to provide flexible fibers of different electrical conductivity having a non-electrically conductive surface.

Detailed Description Text - DETX (21):

The carbonaceous fibers may be used alone or blended with other synthetic or natural fibers. Preferable are the fibers which have been previously used as camouflage materials as herein before described.

Detailed Description Text - DETX (25):

The metallized carbon fibers possess greater electrical conductivity than the non-coated carbon fibers. Moreover, the metallized non-linear carbon fibers can be processed better than metal fibers.

Detailed Description Text - DETX (27):

Beside its use in camouflage structures, the same carbonaceous materials can be used to provide a composite material for electromagnetic shielding. The function of electromagnetic shielding is to eliminate or at least reduce the amount of energy radiated into a certain space or the electromagnetic radiation emitted from a space. Shields of this type are variously required for avoiding extraneous diffusion into cables and electronic circuits, for suppressing unwanted broadcasts from monochromatic or even wide-band stations or even for personnel protection in the microwave range. The metallized form of the carbonaceous fibers is particularly of use in connection with microwave radiation. The shielding effect is more intensified when there is non-uniformity in the shielding material such as when a non-linear fiber is utilized.

Detailed Description Text - DETX (28):

Also a combination of metallized fibers and non-metallized fibers in a textile sheet form provides the optimum absorption and reflection and therefore a higher shielding effect.

Detailed Description Text - DETX (31):

Web material was made with 11/2 inch staple of PANOX (oxidized polyacrylonitrile fiber obtained from R. K. Carbon Fibers, Inc.) heat treated at 550-650 degrees Celsius and from 6 inch cut tow of PANOX using heat treated at 950.degree. C. The material was separated into a fiber web using a Shirley Lab Trash Analyzer in the ASTM Cotton Physical Testing Lab at the Textile Engineering Department at Auburn University. The 11/2 inch staple material was used to make spun antistatic polyester yarn and knit cloth.

Claims Text - CLTX (1):

1. In a structure for absorbing and/or reflecting radiated energy or electromagnetic radiation, the improvement which comprises 1) means for absorbing incident radar waves for reducing target signature and 2) at least one layer of a non-flammable fluorinated or non-fluorinated carbonaceous material having a LOI value of at least 40 for absorbing radiant energy, said carbonaceous material consisting of at least one of foam, film, linear and non-linear non-graphitic fibers and non-linear graphitic fibers.

Claims Text - CLTX (2):

2. The structure of claim 1 wherein said at least one layer comprises a woven or nonwoven web.

Claims Text - CLTX (5):

5. The structure of claim 1 wherein said carbonaceous material comprises fibers having a carbon content of at least 85% and are electrically conductive.

Claims Text - CLTX (6):

6. The structure of claim 1 wherein said at least one layer comprises carbonaceous material of varying electrical resistance.

Claims Text - CLTX (7):

7. The structure of claim 1 wherein said at least one layer comprises a mixture of linear and non-linear carbonaceous fibers.

Claims Text - CLTX (8):

8. The structure of claim 7 wherein said at least one layer comprises a mixture of carbonaceous fibers and non-carbonaceous fibers.

Claims Text - CLTX (9):

9. The structure of claim 7 wherein said at least one layer comprises a mixture of conductive and non-conductive fibers.

Claims Text - CLTX (11):

11. The structure of claim 1 wherein said at least one layer contains dipole materials or magnetic materials blended therein.

Claims Text - CLTX (12):

12. A camouflage structure for attenuating infrared radiation, comprising at least one flexible layer of a flexible electrically non-conductive non-flammable fluorinated or non-fluorinated carbonaceous material consisting of at least one of film, foam, linear and non-linear non-graphitic fibers and non-linear graphitic fibers, at least one flexible layer of an electrically conductive material for absorbing electromagnetic waves and means for providing a three dimensional effect for radar radiation.

Claims Text - CLTX (13):

13. The structure of claim 12 wherein one of said layers is comprises a woven or non-woven web of carbonaceous non-graphitic fibers.

Claims Text - CLTX (14):

14. The structure of claim 12 wherein one of said layers comprises a carbonaceous film or foam.

Claims Text - CLTX (15):

15. The structure of claim 12 including fibers and/or metallized carbonaceous fibers.

Claims Text - CLTX (17):

17. The structure of claim 12 wherein one of said layers comprises carbonaceous fibers within a thermoplastic matrix.

Claims Text - CLTX (18):

18. The structure of claim 12 including a layer of radar reflective material and non-carbonaceous material.

Claims Text - CLTX (20):

20. The structure of claim 12 comprising a mixture of dipole materials within one of said layers.

Claims Text - CLTX (21):

21. The structure of claim 12 wherein one of said layer comprises fibers of different conductivities.

Claims Text - CLTX (22):

22. A camouflage material for military targets effective in the range from visible light to radar waves comprising 1) means or absorbing incident radar waves for reducing target signature and 2) at least one layer of an effective amount of radar absorbing carbonaceous material having electrical conductivity consisting of at least one of foam, film, linear and non-linear non-graphitic fibers and non-linear graphitic fibers.

Claims Text - CLTX (24):

24. The camouflage material of claim 22 wherein said at least one layer comprises about 5 to 10% of the volume of fluorinated non-linear carbonaceous non-graphitic fibers in a thermoplastic matrix.

Claims Text - CLTX (25):

25. The camouflage material of claim 22 including an optically camouflaging paint layer.

Claims Text - CLTX (26):

26. The camouflage material of claim 22 wherein said carbonaceous material comprises carbonaceous fibers and natural or synthetic fibers blended with said carbonaceous fibers.

Claims Text - CLTX (28):

28. A flexible camouflage structure which provides a three dimensional effect having ignition resistant and fire resistant properties comprising at least one flexible layer of an electrically conductive non-flammable fluorinated or non-fluorinated carbonaceous material having a LOI greater than 40 for absorbing electromagnetic waves, said carbonaceous material consisting of at least one of foam, film, linear and non-linear non-graphitic fibers and non-linear

graphitic fibers and means for providing differing angles for incident and reflected radar waves.